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Optimal installation of small hydropower plant—A review

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ABSTRACT

Most of the countries have access to large amounts of water through rivers and canal. With this renewable resource, electricity can be generated without polluting the environment. Because of the increasing in electricity demand, it is important to estimate the future potential of hydropower. It would then be possible to plan development through mix of energy and implement measures to control the development of the electricity market by the use of sustainable small hydropower projects.

In the present paper attempt has been made to review the different types of model developed to evaluate the cost of the small hydropower projects. A review on the different types of correlations developed by earlier investigators has also been presented. The present review attempts to cover the benefits such as clean development mechanism (CDM), internal rate of return (IRR) for financial viability of such projects. A review on the different types of optimization techniques is also been presented to minimize the cost of the installation of SHP projects.

Contents

1. Introduction

Energy and development are closely intertwined. Increasing fossil fuel-based energy generation contributes significantly to environmental related problems both locally and globally. Power sectors are facing problem of increasing electricity demand as well as regulation on greenhouse gas emissions. It is crucial to find sustainable generation methods with high efficiency and broad application. Following this criteria there are few possibilities of power generation, such as solar, wind and small hydropower. Hydropower schemes can contribute with a cheap source, as well as to encourage the development of small industries across a wide range of new technologies. The energy of flowing water is the, renewable and clean source of electricity. The hydraulic power is one of the oldest forms of energy to mankind and used for irrigation and industry. Nowadays, small hydropower is one of the most valuable sources of rural electrification, which can improve the quality of their life. Multiple propose projects for drinking water and irrigation systems can take the advantage to install small hydro schemes [1,2].

Small hydropower systems allow achieving self-sufficiency by using the best possible scarce natural resource that is the water, as a decentralized and low-cost of energy production.

The small hydropower schemes can be associated with different water uses such as:

Power generation and water supply: Water conveyance system used to feed water is supplied to a town through a pressure pipe, from the reservoir to treatment plant are normally equipped with pressure reducing valves (PRV) in order to dissipate excess energy. A turbine can substitute this energy dissipation system if hydropower station is installed in water supply systems to utilize excess energy.

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Power generation and irrigation: Canals take off from the rivers to feed the irrigation system in the alignment of canal, falls are created to negotiable the difference in topographic level of canal and surrounding ground. These falls and the flowing water become the source of small hydropower.

Power generation and flood prevention: Dams can be used to prevent floods by creating reservoirs that should be emptied ahead of the rainy season. The level difference and water releases from the reservoir can be used to generate power.

Power generation and environment protection: Most hydropower projects have dams. Therefore the river habitat is often replaced by a lake habitat. The exploitation of a small hydropower has negligible effect on the environment particularly on the water quality as compared to other power systems. Thus, the hydropower is non-polluting energy source comparing with traditional energy generation systems based on fossil fuels or radioactive components [3,4].

2. Small hydropower technology

The hydro turbines convert water pressure into mechanical shaft power that can be used to drive an electric generator. The power available is proportional to the product of head and discharge. The mechanical power, P (in W), produced at the turbine shaft can be estimated as

$$P = \eta_t \rho_w g Q h \tag{1}$$

where η_t is the hydraulic efficiency of the turbine, ρ_w the density of water (kg/m^3), g the acceleration due to gravity (m/s^2), Q the discharge (m^3/s) and h is the head of water acting on the turbine (m).

In a typical small hydropower scheme, water is taken from the river by diverting it through an intake weir. The weir is a man made structure constructed across the river, which maintains a continuous flow through the intake. The water passes through a desilting tank in which the water is slowed down sufficiently for suspended particles to settle down before descending to the turbine. In medium or high-head installations, water is carried to the forebay by a canal. In low-head installations, generally water entering the turbine is directly from the weir. A pressure pipe, known as a penstock, conveys the water from the forebay to the turbine. All installations need to have a valve or gate at the top of the penstock to regulate the flow. The turbines have hydraulic efficiencies in the range 90% [2,4].

3. Research review

An attempt has been made to briefly review the previous works related to technologies and cost optimization of small hydro power plant.

3.1. Technology

The basic components of small hydro scheme are broadly classified as civil works and electromechanical equipments. The civil work of a small hydropower scheme generally comprises of; structure for water storage and/or diversion, like a dam/barrage or weir; Desilting tank – to remove the silt from diverted water to minimize erosion; Forebay – a simple structure provided at the end of water conductor with some storage capacity for meeting immediate water demand; Penstock – a water conveying system to transport water to the turbine. Spilling arrangement is also provided to spill the excess flow from the forebay in case of shut down of the power house or running at partial load; Power house Building – is a simple structure housing the generating units and control arrangement; A tailrace flow discharging conduit of open channel that conveys the water out of the turbine to the river. The electromechanical equipment of a small hydropower scheme comprises of: turbines, coupled with generators and control equipment [5].

Barros Carlos and Peypoch [6] analysed the technical efficiency in the hydroelectric generating plants, investigating the role played by increase in competition and regulation. The analysis was based on a random frontier model. This model allows the incorporation of multiple inputs and outputs in determining relative efficiency, alongside the separation of homogenous and heterogeneous variables in the cost function.

Paish [7] studied the present technology and current status of small hydropower. It was found that hydropower on small scale is one of the most effective energy technologies. Survey was done on the current status of hydro potential, i.e. how much is technically available and how much is economically viable and how much is yet to be exploited. Although the initial capital cost in setting of a hydro plant may be high, but its long term reliability and lesser environmental effects cannot be ignored.

Williams and Simpson [8,9] discussed about the pico hydro scheme, which are cost effective option for remote off grid rural electrification. Pico hydro scheme, generation cost is lower than small petrol or diesel generators, wind turbines or photovoltaic (PV) systems. It was also discussed that to get low installation cost per unit power output, it is necessary to select the components of the schemes which can reduce the cost and increase the reliability and efficiency of the system.

Wu and Wu [10] presented a case study of ZhongDaSanChuan (ZDSC) hydropower station whose strategy is based on the SWOT analysis. The social environmental effect faced by small hydropower enterprises (SHEs) due to political, economic, social, cultural, technological and natural environments is analysed based on the theory of strategic environmental analysis.

Dursun and Gokcol [11] and Yuskel [12,13] investigated present status of hydroelectric power in Turkey and illustrated the benefits of hydropower, which led to the sustainable economic development and increase in the quality of life. Further Akpınar et al. [14] studied the development of hydropower plant in the Çoruh river basin of Turkey. Author also presented comparison of the hydropower potential of Turkey and Europe with respect to World's potential.

3.2. Simulation model

Karlis and Papadopoulos [15] developed a computer program for performing a preliminary evaluation of small hydroelectric (SHE) system installations. This program provides the user with sufficient technical and financial information in order to justify further investment. It also accessed precise non-financial attributes, such as local/national environmental and socio-economical impacts. This program also takes into account the specific techno economical constraints.

Garrido et al. [16] developed a new simulation tool for small hydropower plants with a run of river scheme and presented the design of a component library for modeling hydropower plants. A general model of hydropower plant with run of river scheme was created. The component library for hydropower plants was designed using OOM (Object Oriented Modeling) language, like EcosimPro software. The result obtained from the simulator exhibit good agreement between the developed tool and the real data. It also presented that simulator can also be used to study an approximated way the behavior of the plant in unusual or unexpected conditions like a great flood of the river.

Anagnostopoulous and Papantonis [17] and Liu et al. [18] presented numerical method used for the optimal sizing of a plant comprising two hydraulic turbines operating in parallel. An analy-

sis of plant performance was conducted using evaluation algorithm. This algorithm simulates in detail the plant operation and computes its production results and economic indices. A parametric study was performed in order to determine the impact of some important construction and operation factors. A stochastic evolutionary algorithm was implemented for the optimization process. The result demonstrated that, the use of two turbines of different size can enhance both the energy generation of the plant and the economic result of the investment.

Almeida et al. [19] presented that the analysis of hydrological, technical, operational, economical and financial aspect determines the investment of small hydropower plants. These, analysis requires joint action of several experts, consume substantial time and money. To overcome these difficulties a model OPAH was presented. This model uses nonlinear programming for the optimization of project configuration. For hydraulic circuit analysis OPAH model uses numeric simulation model of unsteady flow under pressure. In this an economical and financial simulation model is used to analyze the risk associated and market variability of the project.

Fleten and Kristoffersen [20] demonstrated multi stage mixed integer linear stochastic programming. This programming is used to develop a short term production plan for a price taking hydropower plant operating under uncertainty. In this, the current production is guided by the previous day commitments. This made the short term production planning a matter of spatial distribution among the reservoir of the plant. To make the balance between current profit and expected future profits, water must be allocated among the reservoirs.

3.3. Economic analysis of small hydropower plant

Dudhani et al. [21] demonstrated a systematic and comprehensive approach to extract information for identification and assessment of water resources and its associates such as inhabitation and settlement pattern, forest and vegetation coverage, snow coverage and selection of probable sites for small hydropower projects, etc. from satellite image in a specific manner. In this cost comparison of proposed methodology with the conventional method of survey was not shown.

Andaroodi [22] discussed the standardization of civil works to obtain standard design chart including geometric and volumetric functions. The standardization chart helps the designer to evaluate different alternative of the project according to head, discharge and location. Software was developed for optimization of cost which is used after the standardization procedure. This software help in selection of optimum design discharge or hydraulic power for a certain head.

Singhal and Kumar [23] explained that estimation of cost for various civil structures is a very important aspect for the planning and execution of mini/micro hydropower projects. In this, study cost curves were developed for civil structures based on various projects under construction. These cost curves can be used to estimate the cost of civil structures on the basis of site parameters.

Vores et al. [24] presented an empirical model describing hydro turbine efficiency. The problem of designing small hydroelectric plants has been properly analysed and addressed in terms of maximizing the economic benefits of the investments. An empirical short cut design equation describing optimal size of the plant for wide range of site characteristics and commercially available hydro turbines has been presented. The empirical equation developed is as follows [24]:

$$Q_r = \left[\frac{\gamma q^*_{50}}{1 + (\gamma - 1) q^*_{50}} \left(1 - \frac{q^*_{min}}{q_{max}} \right) \right] Q^*_{max} \qquad (2)$$

Table 1
Short-cut model parameters.

Turbine	γ
Francis	0.422
Pelton	0.369
Axial	0.364

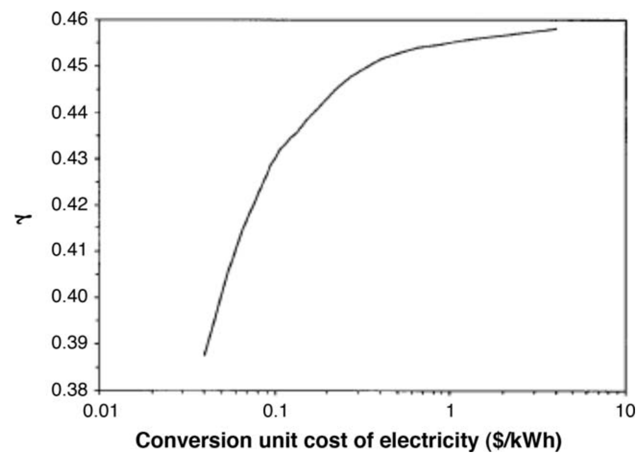

Fig. 1. Effect of conventional unit cost of electricity on short-cut model parameter γ.

where q^*_{50} is flow rate duration curve parameter, defined as Q^*_{50}/Q^*_{max}, q^*_{min} is flow rate duration curve parameter, defined as Q^*_{min}/Q^*_{max}, q_{max} is hydro turbine maximum working flow rate fraction, Q^*_{max} is annual highest stream flow rate (m^3/s), Q^*_{min} is annual lowest stream flow rate (m^3/s), and γ is short cut model parameter.

The short-cut model parameters of different turbines are given in Table 1.

Fig. 1 shows that with the increase in the conventional unit cost of electricity ($/kWh) the value of short cut parameter also increases.

Giudice and Rose [25] studied the potential of chiral blades in extracting energy from flows with low activation energy. A study on design procedure, defining analytical tools and identifying various expenditure, confirming their suitability by the construction of a prototype and its financial characterization as a real device has been presented.

Ogyar and Vidal [26] obtained the equation to determine the cost of the electro-mechanical equipments based on the parameters of small hydropower plant, i.e. head and power. The equations obtained are also dependent upon the type of turbines, i.e. Pelton, Francis, Kaplan and semi Kaplan as shown in Table 2. The cost includes the ex-work market price of the electro-mechanical equipment. The result obtained helped in determining the initial investment when planning renovation or new construction of SHP project.

Fig. 2 shows the variation of real cost to that of simulated cost per kW for different power house in different European countries. It was seen that the simulated cost is much closer to the real cost.

Fig. 3 shows the relationship between the real cost to that of the cost developed by different authors. It was found that many of

Table 2
Summary of cost equations.

Type of turbine	Cost function (€/kW)
Pelton	$17.693P^{-0.3644725}H^{-0.281735}$
Francis	$25.698P^{-0.560135}H^{-0.127243}$
Kaplan	$33.236P^{-0.58338}H^{-0.113901}$
Semikaplan	$19.498P^{-0.560135}H^{-0.127243}$

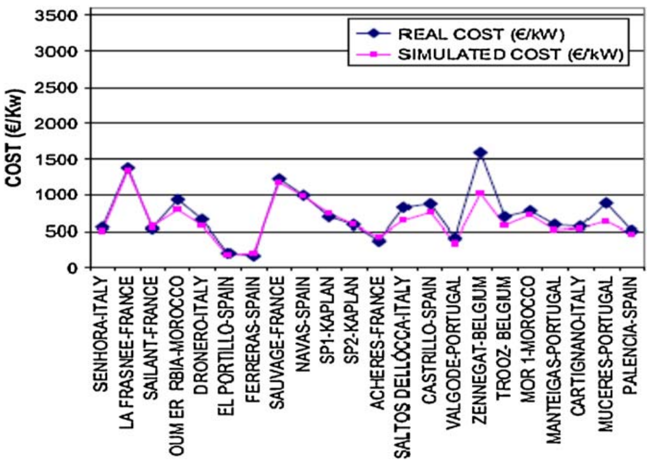

Fig. 2. Real cost vs. simulated cost.

the cost equation obtained were approximately same to that of real cost. Thus these equations can be used for estimation of investment for the refurbishment or construction of new small hydropower plant.

Varun et al. [27] studied the life cycle analysis of three run of river hydropower plants. The energy payback period of these power houses varied from 1.28 to 2.71 years and Green House Gas (GHG) emissions varied from 35.29 to 74.88 g CO_{2eq}/kWh$_e$. In this study it is presented that energy payback and GHG decreases with decreases with increase in the capacity of power house. The energy payback period and GHG emissions for SHP generation system are less as compared to conventional type of electricity generation systems.

Pinho et al. [28] studied the results of 1-year research project aimed at assessing the quality of Environmental Impact Assessment (EIA) studies carried out for small hydropower plants (SHPs) in Portugal. In this study analysis of all EIA reports those were basis of successful EIA processes involving small scale projects of last two decades were carried out. It was found that it cannot be taken for granted that, once an EIA report is formally accepted, its quality standard is consistently of a satisfactory level. The evaluation exercise revealed a number of technical and methodological weaknesses in a sufficient percentage of cases.

Tanwar [29] discussed the global climate change mitigation policies and their stress on sustainable development. Author discussed a new approach to judge the additionality of standalone small hydropower project. This has been done by breaking up additionality into two components: external and local. Using this, the additionality of the CDM projects can be judged in a much easier and accurate way. Purohit [30] studied the CDM potential of Small Hydropower projects in India. It was estimated that, there is a vast theoretical potential of carbon di oxide mitigation by the use of SHP projects in India. In this study the annual Certified Emission Ratio (CER) potential of SHP project in India was estimated to reach 24 million tones approximately.

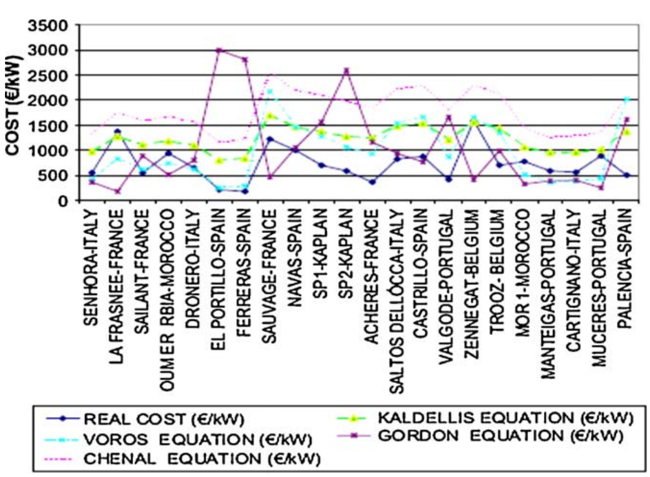

Fig. 3. Real cost vs. analysed cost.

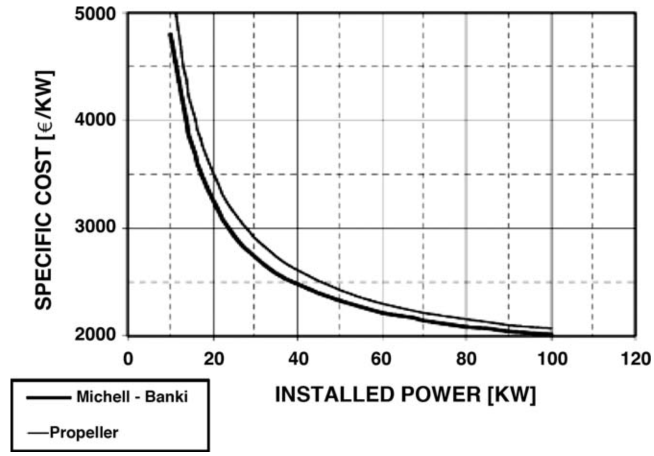

Fig. 4. Investment cost with reference to the installed power concerning Michell–Banki and propeller turbine.

Forouzbakhsh et al. [31] reviewed the structure of Build Operate and Transfer (BOT) contract. Since, a large amount of investment is needed for construction of these power houses. This obstacle can be removed by assigning these affairs to private sectors by using BOT method. The economic evaluation based on BOT method in providing the expenses of small and medium hydropower plant demonstrates that the economic indices and Net Present Value (NPV) improve substantially.

Montanari [32] presented an original method for finding out the most economically advantageous choice for the installation of micro hydroelectric plant. The method was based on the use of economic profitability indicators such as Net Present Value (NPV). NPV is calculated using the plant project parameters, the nominal flow rate, head and the particular hydrologic characteristics of the site.

The result is given in terms of specific cost, with reference to the installed power. In practice the cost of the turbine correlates much more with the flow rate than with the power rating. However, once a site has been found, the head is the same for the two plant configurations and it should be considered to be constant with reference to flow rate if the intake construction provides a long weir. For this reason it is possible to compare the specific costs, with reference to the installed power.

As can be seen in Fig. 4, the costs have a hyperbolic curve, which is very similar for the two plant configurations. It is also shown that with the increase in the installed power the specific cost per kW decreases.

Once the number of years of working life for the plant n has been fixed, together with the interest rate i, it is possible to evaluate the differential ΔNPV [32]:

$$\Delta \mathrm{NPV} = \eta_{\mathrm{Im}} \rho g H c_{\mathrm{kWh}} T \frac{(1+i)^n - 1}{(1+i)^n i} \times \left[\Delta Q^*_{\mathrm{netta}} - \frac{Q_{\mathrm{nom}}(1+i)^n i}{c_{\mathrm{kWh}} T((1+i)^n - 1)} (c_{\mathrm{B}} - c_{\mathrm{P}}) \right] \quad (3)$$

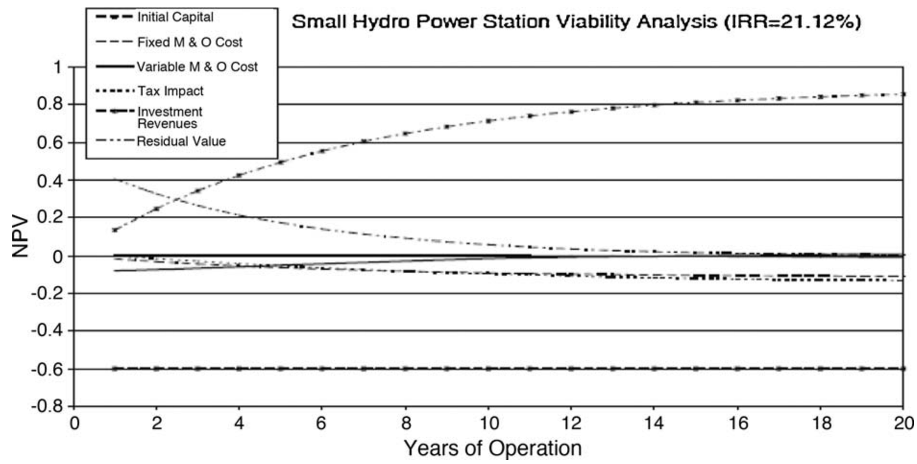

Fig. 5. Viability analysis of a SHP station—IRR prediction.

As a function of the values assumed by the NPV differential, the following cases can be identified:

1. $\triangle$NPV > 0: it is more profitable to install a Michell–Banki turbine than a propeller turbine.
2. $\triangle$NPV = 0: condition of indifference.
3. $\triangle$NPV < 0: it is more profitable to install a propeller turbine than a Michell–Banki turbine.

where η_{Im} is the plant efficiency net of turbine efficiency, ρ is the fluid density (kg/m^3), g is the gravitational acceleration (m/s^2), H is the head (m), T is the period of analysis (for example, a solar year), c_B and c_P represent the specific amortization rate, and Q_{nom} is the nominal flow rate (m/s^3).

Kaldellis et al. [33] presented the study on the systematic investigation of the techno-economic viability of small hydropower stations. A sensitivity analysis adopted for local market financial situation in order to en-light the decision maker on the expected profitability of the capital to be invested was presented. The method applied was based on a well elaborated theoretical model, on long measurements and real market techno-economic information. It was predicted that the resulting internal rate of return (IRR) value of SHP installation is greater than 18% for most cases. The IRR value maximizes after 10–15 years of operation as shown in Figs. 5 and 6. It was studied that the installation cost were found putting affect on the viability of similar ventures.

The following expression for plants located in Greece express the cost of SHP [33]

$$C = (1+\xi)3300(P^{-0.122}H^{-0.107}) \quad (€/\text{kW}) \tag{4}$$

where ξ is currently takes values for the local market between 0.3 and 1.0 (the exact value depends on the intangible expenses of similar installations). P is the capacity of the power house in kW; H is the head in m.

Singal et al. [34] developed correlations for the cost of different components of canal based small hydropower (SHP) scheme. The prevailing rates of the actual quantities of various items were used to determine the cost. The developed correlation give the plant cost as a function of cost sensitive parameters for various layouts based on different types of turbines and generators. They have developed the optimum selection of layout based on installation cost, generation cost and benefit cost ratio at different load factors.

Singal and Saini [35] and Singal et al. [36] determined the cost of different components of a low head SHP scheme based on available head and capacity. The cost obtained from the correlation and the actual cost of the existing hydropower plant were compared and it was found that the cost obtained from correlation can be used to determine the initial investment of SHP project.

Kaldellis [37] suggested that due to opposition of local communities towards new large power station in Greece, small hydro plays an important and vital role in producing the required electricity. A detail reviews on the existing situation of small hydropower plant in Greece was presented. An investigation of their future prospects

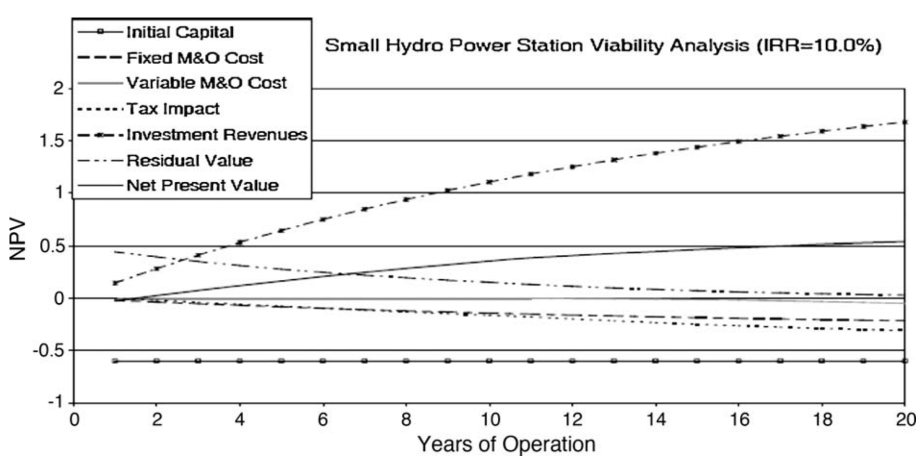

Fig. 6. NPV variation for a selected SHP station in the course of time.

Table 3
Correlation for cost of dam – toe SHP scheme [40].

Components of work/equipments	Cost per kW for alternative layout (Rs.)			
	With one unit	With two units	With three units	With four units
Civil works				
Intake (C_1)	$14382P^{-0.2368}H^{-0.0596}$	$17940P^{-0.2366}H^{-0.0596}$	$21191P^{-0.2367}H^{-0.0597}$	$24164P^{-0.2371}H^{-0.06}$
Penstock (C_2)	$4906P^{-0.3722}H^{-0.3866}$	$7875P^{-0.3806}H^{-0.3804}$	$9001P^{-0.369}H^{-0.389}$	$10649P^{-0.3669}H^{-0.3905}$
Power house building (C_3)	$62246P^{-0.2354}H^{-0.0587}$	$92615P^{-0.2351}H^{-0.0585}$	$121027P^{-0.2354}H^{-0.0587}$	$146311P^{-0.2357}H^{-0.0589}$
Tail-race channel (C_4)	$28164P^{-0.376}H^{-0.624}$	$28164P^{-0.376}H^{-0.624}$	$28164P^{-0.376}H^{-0.624}$	$28164P^{-0.376}H^{-0.624}$
Electro-mechanical equipments				
Turbine with governing system (C_5)	$39485P^{-0.1902}H^{-0.2167}$	$63346P^{-0.1913}H^{-0.217}$	$83464P^{-0.1922}H^{-0.2178}$	$101464P^{-0.1920}H^{-0.2177}$
Generator with excitation system (C_6)	$48568P^{-0.1867}H^{-0.2090}$	$78661P^{-0.1855}H^{-0.2090}$	$105046P^{-0.1859}H^{-0.2085}$	$127038P^{-0.1858}H^{-0.2085}$
Mechanical and electrical auxiliaries (C_7)	$31712P^{-0.1900}H^{-0.2122}$	$40860P^{-0.1892}H^{-0.2118}$	$49338P^{-0.1898}H^{-0.2080}$	$56625P^{-0.1896}H^{-0.2121}$
Main transformer and switchyard equipment (C_8)	$14062P^{-0.1817}H^{-0.2082}$	$18739P^{-0.1803}H^{-0.2075}$	$23051P^{-0.1811}H^{-0.2080}$	$26398P^{-0.1809}H^{-0.2079}$
Cost per kW of civil work (C_c) (Rs.) = $C_1 + C_2 + C_3 + C_4$				
Cost per kW of electro-mechanical equipment (C_{em}) (Rs.) = $C_5 + C_6 + C_7 + C_8$				
Total cost per kW (Rs.) = $1.13(C_c + C_{em})$				

as far as the energy, economic and environmental contributions were also presented.

3.4. Optimization of cost

Minott and Delisser [38] presented cost reduction considerations in small hydropower development. In this author discussed on the main tasks in SHP plant development such as site survey and evaluation, hydrology, geological survey, engineering geology, mapping, etc. were presented. Author also discussed on ways of reducing capital costs in the developing countries such as cost reduction in penstock may be achieved by the use of PVC, wood, fiber glass, reinforced polyester, polyethylene and asbestos cement, etc.; cost reduction in sped control device can be achieved by the use of electronic sensors rather than going for conventional method of speed control of turbine; cost reduction in case of turbines can be achieved by the use of reverse pump prime movers rather than going for separate turbine and pumps; digital device should be used in sensing and control of voltage, they are essentially error free when used in such application as voltage regulation. The cost may be reduced by standardization of parts and reduction of equipment variety being used.

Ogayar et al. [39] presented the analysis of the cost for the refurbishment of small hydropower plants. A series of simple equations were developed for viable study on the refurbishment of a small hydropower based on the economic optimization of the different elements. The equation developed obtains approximate cost for the refurbishment of old hydropower plants or the construction of new ones. Singal and Saini [40] used regression analysis based on actual quantities of various elements of a dam toe SHP and prevailing rates to determine the correlation for cost under low head. These correlations shown in Table 3 where taken as basis for determining the cost of the scheme having number of units. These correlations can be further modified for different condition such as type of turbine, type of generators and soil condition.

Bockman et al. [41] presented a real options approach for making the optimal investment decision in small hydropower plants. In this study the investment decisions were divided into two steps. First to find the value of the project, if constructed and the investment cost. These two functions combined to find the function for the optimal size of the plant as a function of the long term risk adjusted price of electricity. The real option approach also takes into account the possibility to postpone the investment decision to get more information about project profitability.

Jiandong et al. [42] discussed that small hydropower technology should be cost-effective and suitable for local conditions for sustainable development. The cost effective SHP technology should have characteristics such as openness, i.e. open to and adopted by the local people for large scale development in rural areas, appropriateness, i.e. appropriate and suitable for the local conditions and its socio economic development level. It should be suitable for technological transfer, cost effectiveness, i.e. attention to optimizing the planning and designing.

Hosseini et al. [43] determined the optimal installation capacity of the SHP plant and estimated its optimal annual energy value. A program was developed to analyze and estimate the economic

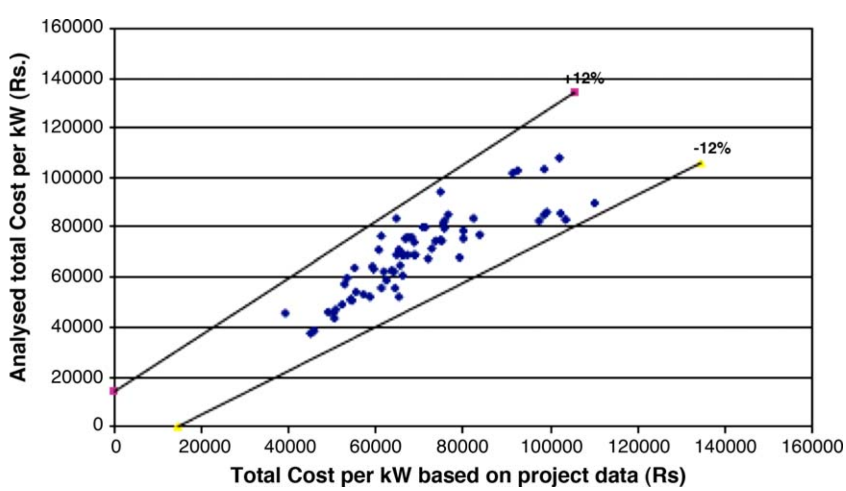

Fig. 7. Comparison of total cost per kW as analysed with collected project data.

indices of an SHP plant using sensitivity analysis. Another program using the Monte Carlo method (technique) was developed to calculate the reliability indices for a number of units of an SHP plants subjected to specific load. Optimal installation capacity of an SHP plant was determined by comparing the technical, economic and reliability indices.

Borges and Pinto [44] presented a model for evaluation of SHP plant generation system reliability and generation planning. The model considers the uncertainties of river flows and generation units operation. Multiple state Markov chain was used to model river inflow. Two state Markov model was used to model generator units. The statistical clustering technique *K*-mean was used to reduce large number of different inflow values. The expected value of the annual power generation of the SHP plant, the duration curve and several reliability indices were calculated more accurately that the conventional approach.

Nouni et al. [45] presented the techno-economic feasibility evaluation of micro hydropower projects being planned and implemented for decentralized power supply for remote places in India. An analysis on capital cost, cost per unit of rated capacity and relative cost of different sub-systems of micro hydropower projects was carried out. Unit cost of delivered electricity and measures of financial performance for the micro hydropower project were also determined. Breakeven values for useful life, plant load factor and unit cost of electricity to the user were also estimated.

Singal and Saini [46] discussed the advantages of low head canal based small hydropower schemes such as near to load centre, easily accessible and assured water availability. Cost correlations of different components of canal based SHP schemes were determined. The cost correlations were developed based on different head and capacity. As shown in Fig. 7 it was found that these correlations can be used for estimation of cost of new canal based SHP scheme with an error of $\pm$12%.

4. Conclusion

The review on the research work in the area of optimum installation of small hydropower plant is presented in the present study. Due to diversification in layout/configuration of small hydro plant, a number of cost equations were developed to suit the site conditions.

It was found that number of contributions exists for determining the installation cost using the head and capacity as cost influencing parameter. Similarly different optimization approaches have been used and implemented to obtain the optimum investment required for installation of the plant.

It is observed that the investment cost determination by the use of other parameter such as discharge, speed of the generator, number of poles of the generator, etc. have not been studied. From the study it is found that for the optimization of investment, different methods have been used carried out simple techniques; however it is recommended to use evolutionary algorithm and other new techniques for the optimization of investment.

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